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PATENT SPECIFICATION

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COMPLETE SPECIFICATION.

Improvements in or relating to Condensing, Coalescing and Precipitating Atmospheric Moisture.

I, LUKE FRANCIS WARREN, a citizen of the United States of America, formerly of 5, Nassau Street, New York City, New York, United States of America, and now of Government Proving Ground, Aberdeen, Maryland, United States of America, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to a method of and apparatus for effecting coalescence and precipitation of atmospheric moisture, as well as condensation.

According to my invention artificial rainfall or the coalescence and precipitation or dispersion of fogs, mists, clouds and other atmospheric moisture is brought about by artificial electrification of the atmosphere in and about the fogs, mist, clouds, *etc.* This is accomplished by spraying preferably upon the upper side of the cloud, fog, *etc.*, finely divided particles having an opposite electrical charge from that of the cloud, *etc.*

As is stated above, the clouds may be natural clouds, but they may also be clouds, fogs, mists, *etc.*, artificially created in any suitable manner, by utilizing the well known principle that condensation of vapor takes place in the presence of charged particles much more readily than in relatively dust-free air. These artificial clouds may be produced as hereinafter described, and the artificial clouds, etc., thus created may in turn be precipitated, like natural clouds, by treatment with oppositely charged particles.

An important distinction is to be made between causing rain-fall from a naturally formed cloud or dispersing a natural fog, and the actual creation of a cloud or the creation of a fog. A cloud or a fog is a mass of small drops of water suspended in the air (with or without more or less solid particles, as in a smoke fog) and the problem of the invention is to cause these small drops to coalesce into drops sufficiently large to fall as rain. This is distinct from the creation of a cloud, where the water vapor in the air is to be condensed into a mass of minute drops of water in suspension in the air, that is, a cloud or a fog. The invention has its greatest application to natural clouds or fogs, although as hereinafter described, it may also be employed to create clouds and fogs, and thereafter, if desired, to cause rain-fall therefrom.

It is of course well known theoretically that clouds or fogs could be formed by ionization of the atmosphere containing the water vapor, and it had been expected by prior inventors that the condensation produced by this ionization would be sufficient to cause a rain-fall therefrom. Such processes have never come into practical use, because the condensation obtained is not sufficient to secure the desired rain-fall or fog dispersal on a commercial scale.

It has also been proposed to provide a captive balloon provided with two devices, one for the purpose of ionizing the surrounding atmosphere to provide nuclei upon which aqueous vapor may condense, and the other to establish and maintain in said zone a condition of electrification of opposite sign to that naturally acquired and possessed by the aqueous particles contained therein, with the intention of creating a condition whereby water particles in close proximity to each other are possessed of electrical charges of opposite sign and consequently attract each other, coalesce, and then fall under the influence of gravity. Apart from the relatively small

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area treated by this process (200 to 300 feet), it will be seen that it also suffers from the defect that each water particle can coalesce with but one other water particle, thereby still further limiting the practicability of the process.

The production of artificial rain-fall or dispersion of fog presents the problem that large areas must generally be considered, as well as the time element. The invention solves the problem by providing rapidly operating means for producing rain-fall or fog dispersion by the employment of an aeroplane or other dirigible aircraft as part of the means of carrying out the invention.

The present invention has two aspects, (*a*) the causing of rain-fall or dispersion of fog from naturally existing clouds or fogs, and (*b*) the artificial creation of clouds or fogs, and the subsequent production of rain-fall or dispersal thereof, both the artificial creation of the cloud and fog and the dispersal thereof employing different means than heretofore which will be enlarged upon in the specification. In the case where an atmospheric stratum is sufficiently saturated with water vapor, and no visible cloud exists, then according to the invention, dust will be scattered by an aeroplane or other aircraft travelling above or in said stratum, said dust having an electrical charge which may be opposite to that of the stratum. The precipitation of the cloud or fog thus formed, may then be expedited by treating it with particles having an opposite charge to that of the cloud so formed.

Meteorologists have shown that dust plays a vital part in the formation of clouds, fogs, mist and other meteorological phenomena due to atmospheric moisture and elaborate researches by C. T. R. Wilson of Cambridge, England, and other distinguished scientists have demonstrated that water vapor in the atmosphere condenses much more readily upon dust particles, as nuclei, than it will condense in dust free air. It has also been shown by elaborate scientific researches that a particle of atmospheric moisture carrying an electric charge has a tendency to grow in size even under conditions so adverse to enlargement as to cause uncharged drops of similar size to evaporate, the theory being that the electric charge diminishes the surface tension of the drops and thus facilitates further condensation and the coalescence of already existing drops.

Scientists have also explained that as the drops of clouds, fog, mist, *etc.*, grow sufficiently in size, the downward pull of gravity increases relatively to and finally exceeds the upward forces which sustain the cloud, *etc.*, in the atmosphere, whethers these upward forces be due to rising air currents, electrical attractions, or repulsions of differently charged atmospheric strata, or other causes. In other words when the drops grow sufficiently large precipitation in the form of rain occurs. This rain may be and often is evaporated before reaching the ground when the atmosphere through which it has to fall is relatively dry and unsaturated. In such cases the atmosphere absorbs the moisture and the cloud, mist or fog disappears. But if the atmosphere through which the rain falls is already more or less saturated with water vapor evaporation is relatively slow and more or less of the rain fall reaches the earth. Indeed, if the atmosphere through which the drops descend is relatively warm and moist, the drops may and often do increase in size as they descend, due to further condensation of water vapor in the atmosphere upon the cold drops falling through it.

Moreover, colloidal chemists have demonstrated that cloud and fog formation partake of the nature of colloidal suspension and hence if certain drops be oppositely charged from the rest and they become enlarged sufficiently to fall, they tend to draw and sweep down with them the other drops in the cloud.

In carrying out my invention the foregoing scientific principles are practically applied to produce coalescence and precipitation, and in certain cases condensation of atmospheric moisture.

Dust capable of retaining an electrical charge is advantageously employed. Fine sand for example is well adapted for this purpose. It is powdered to sizes large enough to slowly fall by gravity through the varying winds and thus be widely dispersed. Such dust having three trillion or more particles per cubic centimeter may advantageously be used. The term trillion is used to denote the square of a million. When it is desired to secure precipitation or dispersion of clouds at a definite locality, larger dust that will fall with less wide dispersion may be used. Several hundred pounds of dust are carried up in an airplane or other suitable aircraft to be charged and sprayed in or upon the cloud, fog or mist, *etc.*, desired to be precipitated. Before discharging the dust it is important to determine the sign of the electric charge of the cloud to be precipitated and that of the atmospheric field above it. The cloud may have a negative potential relative to the atmospheric field above it, or the cloud may be positively charged and the field above it negatively charged, or

a cloud may be neutral and the field above positive or negative, or the cloud may be positive or negative and the field above neutral. Any of these conditions is favourable to my process. Under these conditions the aircraft ascends some five hundred or a thousand feet above the cloud and then discharges into the atmosphere the dust particles, each particle advantageously having upon it the largest practicable electric charge of sign opposite to that of the cloud. Suitable apparatus is hereinafter described. Since the aircraft may travel at a speed of 60 miles or more an hour, while the descent of the dust is relatively slow and the number of minute particles is enormous, very large areas may be sprinkled with these charged particles. Moreover, the particles on falling are further spread about by breezes and gusts thus covering still larger cloud areas.

If both the cloud and the region above it be both positively charged, or both negatively charged, then conditions may not be so favorable for scattering the charged dust, since it may lose part of its charge in passing through the oppositely charged atmospheric strata above the cloud. In such cases it may be advantageous to scatter the dust in the cloud but near its top side.

On the other hand where the atmosphere above the cloud is sufficiently charged with electricity of opposite sign from the cloud, dust may be charged sufficiently in falling through such highly charged atmospheric fields to be capable of assisting in producing precipitation without resorting to direct charging of the dust prior to scattering the same. It is advisable to charge the dust by a suitable apparatus in all cases, however, to increase its efficiency.

In the case of a neutral cloud it is sometimes advantageous to treat the cloud first with particles having a positive or negative charge and then with particles having a charge of opposite character.

In cases where an atmospheric strata is sufficiently saturated, although no visible cloud exists, I may produce condensation and cloud formations by scattering dust above such strata. The precipitation of the cloud or fog thus formed may then be expedited by treating it with particles having an opposite charge to that of the cloud so formed.

The following is an example of apparatus adapted for charging and scattering dust. Referring to the drawing Fig. 1 is a diagram of an arrangement of apparatus suitable for charging the dust at the time of its discharge into the atmosphere. Fig. 2 is a detailed section of dust charging nozzle. The alternating current generator 1 supplies an alternating current of any suitable frequency through a controlling switch 2 to the primary winding 3 of a step-up transformer 4. The generator 1 may be driven directly from the engine of the airplane or by a fan or other suitable means. The secondary winding 5 of the transformer 4 is wound to give a high voltage of the order of 50,000 volts. The two terminals of the secondary winding connect to the plates 6 of two thermionic rectifiers 7, each provided with a filament 8, the latter with the plate 6 being sealed in a highly exhausted glass chamber. The filaments 8 are heated by the common battery 9 which is carefully insulated from the framework of the airplane. A wire 10 connected to the filaments and another conductor 11 leading from the middle point of winding 5, connect to the terminals of a suitable storage condenser 12. The condenser 12 is connected through a highly insulated reversing switch 13 to the two terminals of a suitable nozzle 14 for charging the sand, dust *etc.* This sand-charging nozzle is further described below. The outer terminal of the nozzle is grounded to the frame of the machine as at 15.

Above the nozzle and connected to it by a narrow throat or pipe is a hopper or funnel 16 by means of which sand is supplied to the nozzle 14. The throat 17 is provided with a slide or valve 18 by means of which the throat may be closed when the apparatus is not in use and which may be used to regulate the rate of flow of sand when the apparatus is in operation. The arrangement shown in Fig. 1 is, however, given to represent diagrammatically a method of accomplishing the results claimed by the invention.

One form of charging the nozzle is shown in Fig. 2 and is described below. In order to charge the dust, the particles must pass through an intense electric field while in contact with a conductor electrically charged, the sign of the charge being that desired on the dust. The nozzle in Fig. 2 consists of a central metal rod or cylinder 20 provided at one end with a connecting wire 21. The conductor 20 fits tightly at one end into an insulating cylindrical envelope 22 which, although fitting tightly the conductor 20 at one end, is larger in diameter than the conductor 20 at the other end so that there is annular space 23 between the conductor 20 and cover 22, through which dust or sand may pass when fed through the supply pipe 24, a part of the cover 22. This insulating cover 22 may be

made of glass, quartz, mica or any other electrical insulator. Around the cover 22 is a cylindrical piece of metal 25 provided with a connecting wire 26.

The operation of the apparatus in Fig. 1 is as follows:

The alternating current generated by generator 1 is, when switch 2 is closed, stepped up to say 50,000 volts by the transformer 4. The rectifiers 7 allow the current to pass only when the polarity of the plate is positive, so that the current will pass through one rectifier and into condenser 12 during one half cycle and through the other during the other half cycle, the return wire being in both cases the conductor 11 to the middle top of winding 5. As a result the condenser 12 is charged to a potential approximately one half the peak potential at the terminals of the winding 5.

When switch 13 is closed the potential of condenser 12 is impressed between the conductors 20 and 26 of the nozzle (Fig. 2). Sand or dust in the hopper 16 fed by gravity, passes through the throat and valve 17 and 18 into the nozzle 14. Here it is electrified, the sign determined by the position of switch 13. The nozzle is situated under the airplane or at its tail so that the sand is caught by the rapid stream of air due to the motion of the airplane. This stream of air may assist the discharge of the sand and its dispersion. The charge of sign opposite to that taken by the sand passes to the frame of the airplane through the ground wire 15. This charge may then be dissipated by means of needle points on the trailing edge of the upper wing of the airplane or by the conducting exhaust gases of the engine.

It will be evident from the foregoing that many changes and variations may be made in the particular procedure herein described without departing from the spirit and scope of my invention.

For example, in dealing with the case where a cloud or fog is to be created and thereafter precipitation or rainfall is to take place, instead of using dust particles, it may be desired to employ the well known fact that when ions are scattered in a moisture-saturated atmosphere, condensation is thereby caused; after this, in accordance with my method, the charged dust is spread as hereinbefore described, to coalesce and precipitate the cloud thus formed. It will be obvious that to make this aspect of my process effective, the ions must be scattered over a large area and with not too great a consumption of time, so that when the dust is spread to cause precipitation, the cloud will still be charged. These ions may be scattered from an airplane or other dirigible aircraft, by means of any suitable powerful ionizing means such as x-rays, well-known for this purpose. Another method is to trail from the plane a multiplicity of antennæ or wires all insulated from the plane and connected to one terminal of a unidirectional high potential electrical device such as is shown in Fig. 1. The other terminal of the high voltage device is connected to the frame of the airplane. Dispersing needles are provided on the upper wing of the machine, or other suitable means to dissipate the charge which tends to accumulate on the airplane. Such an arrangement spreads a cloud of ions of one sign below the plane and a cloud of ions of the opposite sign in a strata above the plane. The two clouds of ions should be far enough separated so that the ions do not recombine before condensation begins. After condensation begins, the mutual attraction of the oppositely charged drops in the two strata causes them to coalesce and aid precipitation.

For the effective operation of the method described above, the potential of the electrical device should be sufficient to produce the familiar brush or glow discharge from the ends of the antennæ wire.

Clouds of smoke, dust, and the like, and clouds or vapors of materials other than water, may also be treated and precipitated by the use of the foregoing processes in accordance with my invention.

In the following claims the word "cloud" is used generically to include all forms of condensed suspended atmospheric moisture whether visible or invisible except when specifically stated otherwise.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:—

1. The process of changing atmospheric conditions consisting in traversing an atmospheric zone where it is desired to change the conditions with an aeroplane or other dirigible aircraft and scattering from said aeroplane substances which will produce the desired change of atmospheric conditions, as for example, electrically charged sand, dust or other finely divided particles, adapted to produce condensation or coalescence of water vapor or water particles to produce rain-fall or fog dispersion.

2. The process of producing rain-fall or dispersal of cloud or fog, according to Claim 1, in which the cloud or fog is scattered with particles having an elec-

trical charge of opposite sign to that of the cloud or fog, to produce coalescence of the water particles.

3. The process according to Claim 1, in which the charged particles are scattered upon or through the cloud or fog.

4. The process of changing atmospheric conditions consisting in traversing the atmospheric zone where it is desired to change the conditions with an aeroplane or other dirigible aircraft and scattering from said aeroplane through a substantial area containing water vapor, finely divided particles such as dust, sand or the like, charged with electricity to cause condensation of said water vapor into water particles, and thereafter, if desired, producing coalescence of these water particles, for example, by scattering the cloud or fog with finely divided particles having an electrical charge of opposite sign to that of the artificially created cloud or fog.

5. Method in accordance with Claim 2 or 3 or 4, in which, when the cloud or fog is neutral, it is first charged with electricity of one polarity, and is thereafter treated by scattering therethrough the finely divided particles having an electrical charge of opposite polarity to that previously imparted to the cloud or fog.

6. The process of condensation in free air according to Claim 1, in which the aeroplane or other dirigible aircraft is unconnected with the earth and travels through a substantial area containing water vapor and scatters the electrical charges throughout said area to produce condensation of the water vapor.

7. Process according to Claim 6, in which the aeroplane scatters simultaneously electrical charges of both polarities, and if desired, the charges of opposite sign being scattered in separate strata.

8. Apparatus for changing atmospheric conditions, such as effecting coalescence and precipitation of atmospheric moisture, which comprises an aeroplane or other dirigible aircraft containing mechanism for discharging minute particles of a medium adapted to react upon the surrounding atmosphere.

9. Apparatus according to Claim 8, in which the discharging mechanism comprises a discharge nozzle adapted to have a source of high potential connected therewith, whereby the nuclei or small particles of matter passing therethrough are adapted to have imparted thereto a high potential charge of either sign.

10. Apparatus according to Claim 9, having a receiving hopper for the nuclei or small particles of matter to be scattered cooperating with a discharge nozzle having a pair of terminals adapted to be connected across the secondary of a high potential transformer through the intervention of a rectifying device and thereby to impart a high potential charge of either sign to the particles of matter discharged from said nozzle.

11. The improved method of and apparatus for changing atmospheric conditions, substantially as hereinbefore described and illustrated.

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Fig. 1

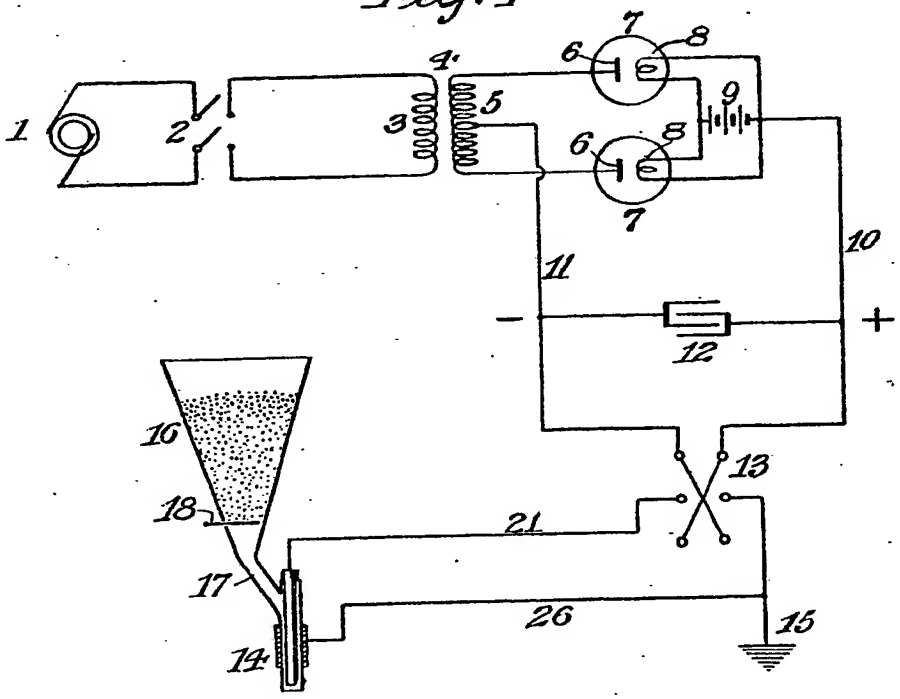
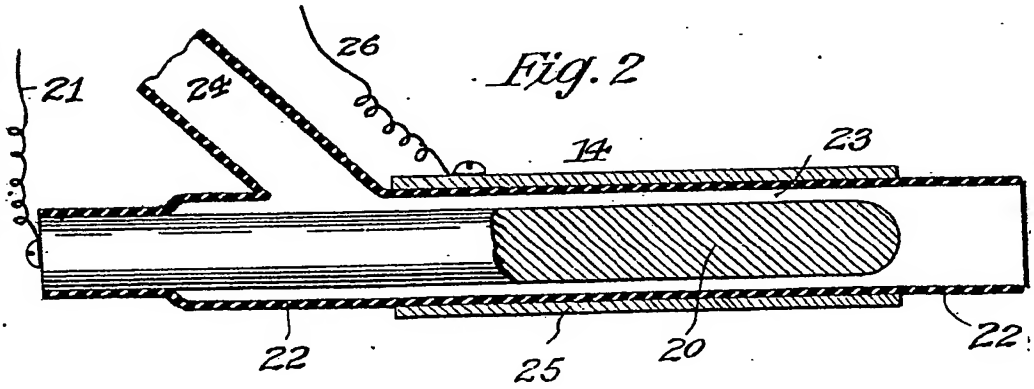


Fig. 2



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